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THESIS

USE OF COMPUTERS IN NAVAL MOBILE CONSTRUCTION BATTALIONS

by

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The existing system was found to be incomplete and inadequate in terms of both hardware and and software. (Continued)

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Information systems used in the private construction industry, while useful, will not satisfy all the requirements for a battalion. It is recommended that a new system be designed utilizing networking techniques and incorporating a data base management system.

Use of Computers in Naval Mobile Construction Battalions

by

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This paper reviews the use of the PDP 11/03s in the Naval Mobile Construction Battalions. The existing system was evaluated against the information requirements of the battalions and recommendations are proposed for hardware and software improvements and for the implementation of the new system.

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I. INTRODUCTION

Computers can be very useful tools in managing organizations and their operations, yet the use of computers by Naval Mobile Construction Battalions has been very sporadic. This paper reviews the use of the PDP 11/03s in the battalions, evaluates the existing system and the battalion information requirements, and proposes recommendations for hardware and software improvements and for the implementation of a new system.

In the early years (the late 1950s and early 1960s) of computerized data processing, the vast majority of business "systems" were intradepartmental financial applications which had been designed for and converted from unit record punched card systems. Many of the early general-purpose computer systems did not have magnetic tape or disk storage and were simply a faster method for processing the punched cards, making the computations, and printing the reports in one step. These application systems, much as the earlier unit record punched card systems, were economically justified on the basis of eliminating steps and clerical effort. As computers became more in vogue in the early 1960s, management went through a subtle change in their decision making related to EDP (electronic data processing). The change related to a shift away from requiring economic justification prior to embarking on new application systems development projects or on upgrading computer hardware. Management seemed to take the position that even though they would not necessarily save money, the use of computers would represent an improved method of operation and provide for future growth. When economics were considered, they were often relegated to future cost containment. [Ref. 1: p. 2]

Today, computer systems are a part of our daily life from making telephone calls to local shopping. In today's modern society it is nearly impossible to spend a day without being affected by or without having affected a computer-based system. [Ref. 2: p. 7]

The computer revolution is already being compared to the Industrial Revolution [Ref. 3: p. 75]. In private industry the use of computers for accounting, stock control, and production process control is widespread. Computers are also used in very sophisticated management information systems. In the construction industry, however, the use of computers for applications other than general accounting has not been prolific. Housing [Ref. 3: p. 75] reports that only a handful of the country's homebuilders and remodelers - a mere 5% to 18% - use a computer system, although another 40% say they are on the brink of joining the revolution. While high-cost help and sinking productivity are factors in the push towards computerization [Ref. 4: p. 55], the revolution in the computer industry caused by microelectronics may be the biggest factor. Microelectronics has caused the cost of hardware to drop dramatically while at the same time given computers greater capacity and portability. Computers are no longer confined to computer centers, but are now found in homes, offices, and on construction sites. The construction industry is looking at ways to automate information handling, design and drafting, and even resource management.

As in the construction industry, the use of computers within the Naval Construction Force, specifically the Naval Mobile Construction Battalions (NMCBs), has had only limited success. Intuitively, it would seem that the need for automation in NMCBs would be similar to that of the construction industry, and, if the construction industry can increase productivity by effective use of the computer, this experience should be transferrable to the battalions.

II. BACKGROUND

A. NAVAL MOBILE CONSTRUCTION BATTALIONS (NMCBS)

The active NMCBs are established units of the Naval Operating Forces and are components of the Naval Construction Force (NCF). The mission of the NMCBs is to provide responsive military construction support to naval, Marine Corps and other forces in military operations, to construct base facilities, and to conduct defensive operations as required by the circumstances of the deployment situation. [Ref. 5: p. 1]

B. INTRODUCTION OF NCF/MIS

The Civil Engineer Support Office (CESO) introduced the Naval Construction Force Management Information System (NCF/MIS) at 5 NMCB overseas deployment sites (Guam; Puerto Rico; Rota, Spain; Okinawa; and Diego Garcia) as well as at the Construction Battalion Centers (CBC) in Gulfport, Mississippi and Port Hueneme, California. The deployment camp at Diego Garcia has since been closed down and that system divided up and sent to Guam and Okinawa.

The NCF minicomputer systems, DEC PDP 11/03s, are permanently installed at the overseas deployment sites and are used by the rotating NCF units [Ref. 6]. The systems at the CBCs are installed at the TWENTIETH Naval Construction Regiment (NCR) at Gulfport and the THIRTY-FIRST NCR at Port Hueneme and are used by the regiments and the battalions in home port. The programs that are provided with the systems are:

1. CONSTRUCTION MANAGEMENT (CM) - This program (CM4) provides the capability to plan and control a project

using Critical Path Method (CPM) networking techniques. The program will develop a network of interconnected activities using either the arrow diagramming (I-J network) or the precedence diagramming method (nodes). Each activity can have up to six resources (men, materials, and/or equipment) from a resource library with a maximum capacity of 99 resources. The program will provide several output formats including:

a. A bar chart which is a graphical plot of activities vs time.
b. A Resource Type By Activity report which shows all activities using a particular resource, the quantity of that resource used by each activity, the resource unit man-days, and the total man-days.
c. A Resource Usage By Activity report which shows for each activity the number, code, description and quantity of each resource required.
d. A Resource Usage Plot which, for a given resource, depicts the quantity of that resource required per project day for critical activities. If the quantity of resource required is more than the maximum quantity available, the excess requirement will be flagged. [Ref. 7: p. 1.03]

2. WORD PROCESSING - This program will generate properly formatted letters, reports, instructions, etc [Ref. 8: p. 1].
3. PEOPLE - This program provides a method for storing and generating reports on the personnel in a battalion. It will store and print various fields including name, address, social security number (SSN), Personnel Readiness Capability Program (PRCP) skills, etc. [Ref. 9: p. 1]

4. SAFETY AWARD - This program maintains safety-related statistics to determine which entity within the battalion has the best period safety record [Ref. 10: p. 1].
5. MEDICAL - This program tracks inoculations, medical examinations, blood type, and urinalysis testing. The program will sort and print on various fields including name, rate, department/company, inoculation, examinations, etc. [Ref. 11: p. 1]
6. EQUIPMENT - This program maintains a data base for the acquisition, movement, and status of all automotive, construction, and material-handling equipment. It will provide various reports including equipment listing, location, custody, availability, cost control, etc. [Ref. 12: p. 1]
7. TOOL - This program will create a data base for all tools within a battalion and provide reports sorted on various fields including tool name and custodian. It will also provide reports for the tracking of electrical safety and preventive maintenance inspections. [Ref. 13: p. 1]

A new program, MATERIAL LIAISON OFFICE (MLO), has been developed and is currently being field tested on Guam. Specific information on this program has not been released yet.

C. ON-SITE VISITS

Post-implementation visits were made to the various deployment sites by representatives of CESO and the THIRTY-FIRST NCR. The results of these visits indicated a very sporadic use of the programs by the battalions. Some programs were used very heavily and others ignored. There was no apparent pattern either between battalions or deployment sites.

D. PROGRAM REVIEW

During an NCF minicomputer conference held at CBC Port Hueneme, CA during the period 27-29 October 1981, representatives from Commander Construction Battalions, U. S. Pacific Fleet (COMCBPAC) and Commander Construction Battalions, U. S. Atlantic Fleet (COMCBLANT) requested that a review of the NCF minicomputer system be conducted to determine whether the system should be expanded and the equipment included as part of the battalion Table of Allowance (TOA), remain unchanged, or be discontinued [Ref. 14].

The Commander, Naval Facilities Engineering Command [Ref. 15] concurred with the review and specifically requested that the review consider the total requirements of the NCF contingency missions and whether utilization of automated data processing (ADP) will enhance readiness to meet these missions. If the contingency missions can be enhanced, only then should the peacetime potential for ADP use be pursued.

III. ANALYSIS OF EXISTING CONDITIONS

The following approach was taken in analyzing the feasibility of integrating state-of-the-art computer systems into the battalions:

1. Determine why the battalions are not using the existing system,
2. Identify the information requirements of a battalion,
3. Evaluate how the current system satisfies these requirements, and
4. Identify the potential use of computers during mobilization.

The following sections discuss each of these points.

A. NON-USE OF THE EXISTING SYSTEM

A review of the programs provided with the existing computer systems suggested that their output should be very beneficial to the battalions. Why, then, was the use of the systems so sporadic?

To get the battalions' point of view, questionnaires were sent to all eight battalions. In conjunction with the questionnaires, interviews with personnel from two battalions in home port at CBC Port Hueneme were also conducted. A compilation of the responses from the battalions, including those obtained during the interviews, is contained in Appendix A.

Table I is a summary of how the personnel that normally use a program characterize the output of that program. The figures are in terms of the number of respondents. In general, there is strong support for all of the programs. Table II summarizes how often the same set of respondents

TABLE I

PROGRAM EVALUATION SUMMARY (NUMBER)

PROGRAM	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
CM4	21	33	3	2	-
WP	6	4	1	4	-
PEOPLE	22	27	7	5	2
SAFETY	2	6	1	-	1
MEDICAL	-	5	2	2	-
EQUIP	12	9	-	-	-
TOOL	5	6	2	1	2

TABLE II

FREQUENCY OF USE SUMMARY (NUMBER)

PROGRAM	DAILY	FREQUENTLY	OCCASIONALLY
CM4	4	19	36
WP	4	2	9
PEOPLE	18	19	26
SAFETY	2	2	6
MEDICAL	-	7	2
EQUIP	9	5	7
TOOL	4	3	9

use each program. As indicated, very few use the programs on a daily basis, which is not surprising for some of the programs given their nature; however, the use of WORD PROCESSING, MEDICAL, and EQUIPMENT was expected to be higher.

During the interviews the following factors were brought out as the main reasons for not using the programs:

1. The survey results notwithstanding, the terminal locations are inconvenient and discourage use. In home port the only system available is located in a regimental building and usually there are two battalions and the regiment all vying for access time. On deployment, the system is usually located in one of the offices and access time is still a problem.
2. Projects were generally considered to be too small to justify the time required to load the CM data base. Most viewed the system as only applicable for large projects that might, in contract terms, exceed $1 million.
3. The system took an inordinate amount of time (hours in some cases) to produce a sorted personnel roster or construction schedule. While the CM or PEOPLE programs were being run, no other programs could be run concurrently thus tying the system up with a single user.
4. The hardware is unreliable, particularly the printers.
5. The system does not provide information that isn't easier to obtain by other means.

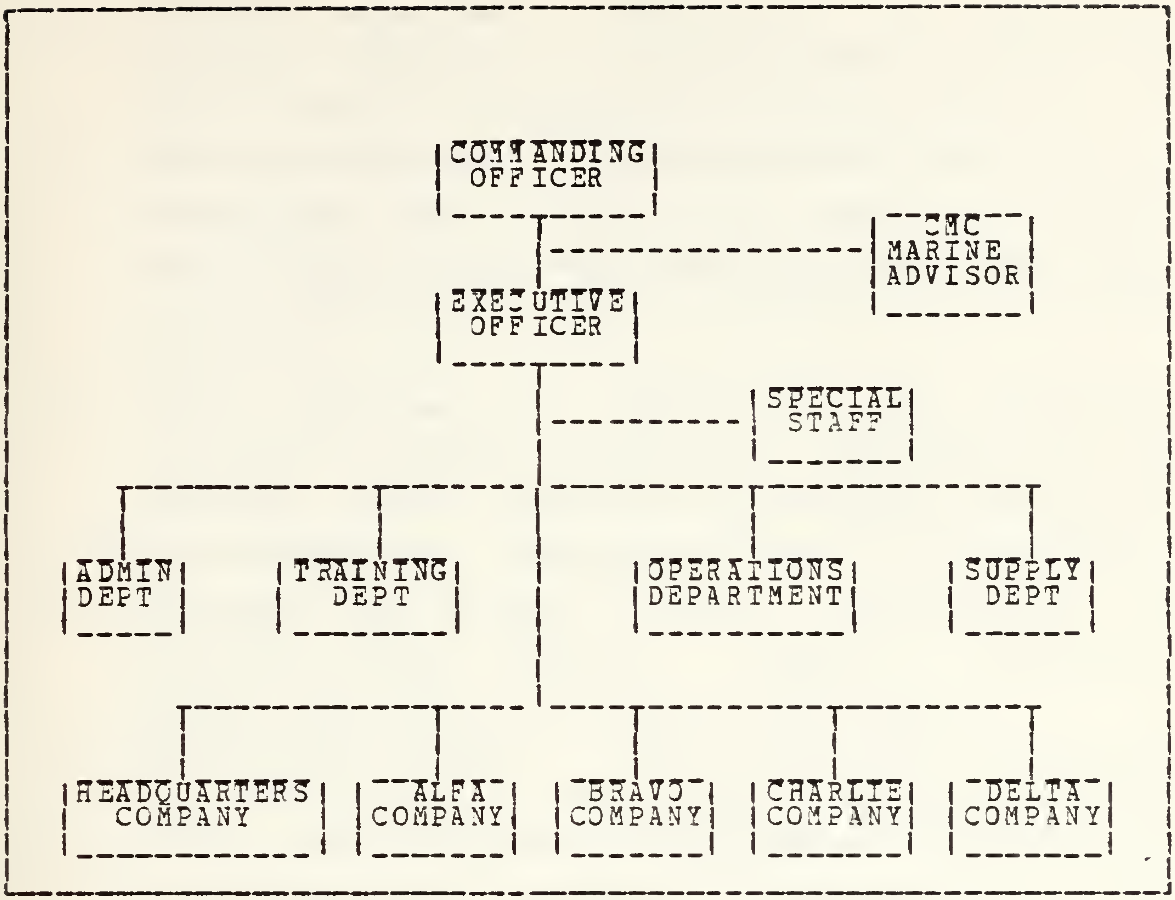

Figure 3.1 NMCB ORGANIZATION.

B. BATTALION INFORMATION REQUIREMENTS

NMCBs have a hierarchial structure as shown in Figure 3.1 and are normally staffed with 700+ Officers and Enlisted. The basic functions of each of the departments/ companies are as follows:

1. ADMINISTRATIVE Department - Provides basic administrative support, such as preparation, routing and filing of reports, correspondence and directives; transfer and receipt of personnel; preparation of the personnel diaries; and maintenance of service records.

2. TRAINING Department - Responsible for contingency planning, intelligence collection, and the scheduling and monitoring of technical and military training.
3. OPERATIONS Department - Responsible for the planning, scheduling and managing of current battalion construction, combat and disaster preparedness operations; construction quality, safety, and engineering support.
4. SUPPLY Department - Responsible for procuring, receiving, storing, issuing and accounting for all equipage, repair parts and construction materials; disbursement of government funds for battalion purchases and military payday; operations of the enlisted dining facility, laundry, barbershop, Central Tool Room, and Central Store Room.
5. HEADQUARTERS Company - The administrative and military organization for all enlisted personnel assigned to the battalion executive and special staff. All enlisted personnel assigned to the staff for their professional jobs are under the functional and technical direction of the staff department head to which they are assigned. The company provides support to the line companies in construction and disaster recovery operations by virtue of the company members being assigned to the military staff departments, but is capable of providing defense in the combat situation as a company unit.
6. ALFA Company - Responsible for the operation and maintenance of the automotive, construction and materials-handling equipment assigned to the battalion. It serves as prime contractor on large earthmoving, paving, and other horizontal construction projects, and as subcontractor to the general construction companies for earth-moving, grading,

excavation, paving, hauling, pile driving, well drilling, heavy lifting, blasting and demolition.

7. BRAVO Company - Serves as a prime contractor for water, sanitary sewer, and power distribution systems, fuel systems, and communication projects. It serves as subcontractor to the general construction companies for all utility installation, sheet metal fabrication, air conditioning and refrigeration. It serves as a mini-public works department providing for maintenance and operation of the unit's camp.

8. CHARLIE/DELTA Companies - Serve as general construction companies in the role of a prime contractor. They will lend support to ALFA and BRAVO Companies in a subcontractor capacity. [Ref. 16]

During peacetime, battalions are on a 6/6 rotation schedule: 6 months in home port and 6 months on deployment. Whether in home port or on deployment, a battalion is engaged in two major operations: (1) executing their current assignments and (2) planning for the upcoming rotation.

During the home port period, personnel are engaged in various types of training: military, factory, Navy schools, and local projects to maintain proficiency. The time period of the training activities will vary from one day to many weeks. A separate training schedule is established for each member of the battalion based upon his own capabilities and prior training and it is highly unlikely that any two members will have the same schedule. At the same time, battalions must also plan for their upcoming deployment.

The current policy is to rotate all battalions through all the overseas deployment sites, regardless if they are Pacific battalions out of Port Hueneme, CA or Atlantic battalions out of Gulfport, MS. The projects assigned come from prioritized lists that are submitted annually by

CINCPACFLT, CINCLANTFLT, and CINCUSNAVEUR and approved by CNO. The TWENTIETH NCR at CBC Gulfport provides support for the Atlantic and European deployment sites by developing material take-offs for each of the projects and ordering and shipping materials procured in CONUS. The THIRTY-FIRST NCR at Port Hueneme and the THIRTIETH NCR at Guam provide similar support for the Pacific sites. In planning an upcoming deployment, a battalion needs information concerning the status of all projects expected to be assigned: those that are under construction as well as those that the battalion expects to start. The information would include the current construction schedule and the schedule of men, material, and equipment requirements for each project.

The reverse is true for the deployed battalion: they must plan for the upcoming home port period while executing the deployment site construction schedule. The planning for home port includes determining personnel losses due to Expiration of Active Obligated Service (EAOS), transfer, etc., and the comcommitant loss in skill level. To reestablish the skill level, training requirements have to be determined and quotas requested and established followed by assigning individual members to each of these quotas.

Every department and company is involved in schedules: material schedules, personnel schedules, equipment schedules, construction schedules, etc. At the moment, most, if not all, of these schedules are developed and maintained manually even though it is this kind of effort for which computers can be used very effectively.

C. EVALUATION OF THE CURRENT SYSTEM

During the construction of any project, it is necessary to bring together in an orderly fashion the requisite labor, material, and equipment. Construction projects are normally divided into their constituent parts and the parts then linked together into some type of time-scaled schedule. This schedule can take the form of a bar chart or a Program Evaluation and Review Technique (PERT) or CPM network. The construction schedule should identify the required daily resources and, from this, individual daily resource schedules can be developed. The resource schedules should cover either the construction period or the deployment period, whichever is shorter. Any change in the construction schedule, either acceleration or slippage, will impact on each of the resource schedules.

The CM program will provide this information as each of the project's constituent parts equates to a program activity. The major drawback of the program is the limited number of resources (6) that can be assigned to each activity. If the project data base is maintained, any company or department can access that data base and obtain an updated schedule. Any change, caused by the project either being ahead or behind schedule, that creates a situation where the project requirements exceed the supply for that project will be flagged so that appropriate action can be taken. The CM program is appropriate and most useful at the project manager or crew leader level as it is this level that is primarily concerned with the day-to-day details of a construction project.

The Company Commander or Operations Officer is generally concerned with a consolidated project schedule on a company or battalion-wide basis, respectively. They are concerned with resource leveling on a broader scale. A change in the

construction schedule for one project will affect the construction schedule for all other projects which, in turn, will affect the total daily resource schedule. An excess or shortage of personnel resources are particularly important since the labor force cannot be hired or fired when the requirements change. The current CM program will not provide this type of schedule and, therefore, if a consolidated project schedule is used, it must be prepared manually.

For a battalion to function effectively, each member must have a daily assignment. These assignments might be leave, TAD, schools, projects, etc. Since most of the departments operate in an office environment, a formal assignment chart is normally used only to post leave, TAD, and training schedules. The charts used by the companies, and possibly the Operations and Supply Departments, would also include project assignments. The CM program allows resources to be attached to each activity in terms of numbers and trade, but not by name. The PEOPLE program will show a company assignment and whether or not an individual is TAD, but neither are tied to time. Therefore, the assignment charts, which are basic personnel management tools, must be prepared and maintained manually.

Battalions are faced with the same administrative requirements as any military unit. Instructions and notices must be prepared, updated, and issued as well as letters, memoranda, endorsements, etc. The WORD PROCESSING program provides the capability to use standard formats and allows for easy changes and updates. By using the data base, much of the hard copy files can be eliminated.

Any construction organization must be concerned with safety as the work is inherently dangerous with severe and fatal accidents not uncommon. Although not specifically applicable to military organizations, OSHA contains

extensive safety regulations that are applicable to construction in general. While it is appropriate that the battalion's safety organization be very familiar with those safety items that are required as well as recommended, it is also appropriate for the project manager or crew leader to be aware of those items that are applicable to each project activity. The current SAFETY program is merely a statistic gathering package and cannot be used as an effective tool to promote safe operations.

The health of its members is a primary consideration of any military unit. The medical staff must ensure that all members of the unit are physically qualified to deploy and to perform those tasks inherent in their rate. Therefore, medical records are maintained and screened periodically to ensure that the necesary examinations and inoculations have been accomplished. The MEDICAL program will sort the data base and provide a listing of all personnel that are due for examination or inoculation. Medical records have traditionally been filed by social security number (SSN) due to the possibility of name duplication. The current program does not provide for a SSN field and, therefore, confusion as to which "BU3 John William Smith, Jr in Charlie Company" is due for a medical examination can occur.

On deployment, the battalions are assigned the custody of a vast array of automotive, construction, and material handling equipment. Some pieces of equipment can be assigned to a department or company on a continuing basis and operated by members of that entity. Other pieces are maintained in a pool with the operation of some strictly limited to Equipment Operators from Alfa Company. Regardless of whether the equipment is on a continuing assignment or not, the maintenance is performed by Alfa Company. The maintenance frequency (e.g. every 3,000 miles, every 100 hours, etc.) will vary by type of equipment.

Although the frequency will be constant within each equipment type, the actual maintenance schedule for each piece will vary depending upon the use. This variable maintenance schedule could impact upon the construction schedule unless a companion operating schedule is kept as well. The EQUIPMENT program will provide a maintenance schedule and also has a field to record the equpment location. A major drawback is that the program will not provide an operating schedule for the equipment. If a crane is needed on one project one day and on another project the next, the schedule must be prepared manually.

The battalions also maintain a large inventory of tools, some of which require special training to operate. When the tools are checked out, custody cards are prepared and maintained until the tools are returned. The TOOL program will generate inventory and custody reports.

D. TRAINING

When the systems were first introduced, the training on the systems was limited to the Officers and Chief Petty Officers. This group received instruction on how to input the data and generate and use the reports. The training has since been expanded to include petty officers. One problem with the training is that Officers, Chiefs, and petty officers are being trained as terminal operators. It is suggested that the training is focused on the wrong level. How to use the reports and which reports are available is appropriate for crew leaders and above, but the instruction on terminal operation (how to access the programs, input data, and generate output) should be given primarily to lower level personnel, i.e. company clerks, etc.

E. POTENTIAL USE OF COMPUTERS DURING MOBILIZATION

During mobilization the NMCBs are intended to provide responsive construction support at Navy support bases in forward areas or in combat zones to which Navy and/or Marine Corps forces are committed. Normally in the combat zone, NMCB-built facilities will be limited to initial, intermediate, and temporary construction standards; however, capability for permanent construction will be maintained. [Ref. 5: p. 1]

In peacetime, NMCBs shall undertake construction projects which maintain their construction capabilities and enhance their readiness to accomplish their contigency mission. In time of emergency or disaster, NMCBs shall conduct disaster control and recovery operations, including emergency public works operating functions, as directed. [Ref. 5: pp. 1 & 3]

The requirements during mobilization and peacetime operations are essentially similar. Men, material, and equipment must be organized and deployed to a particular location to perform a specific task. Hostile action not withstanding, there are two main differences between the peactime and mobilization environments: (1) the planning time horizon and (2) established deployment sites vs virgin territory.

While general planning for mobilization can be accomplished in advance, detailed planning must be tailored to the specific situation, and in all probability will not only involve the battalion, but rear echelon commands as well. General embarkation plans, for example, can be prepared in advance to mobilize all or part of a battalion. Once a data base is established, it can easily be maintained and can be used as the basis for developing a specific situation plan. By having the appropriate programs available, i.e., those

that serve all levels within a battalion, ADP can be an extremely useful tool during the initial mobilization phases.

The usefulness of ADP at a forward site will depend upon the anticipated length of the engagement and whether the appropriate facilities are available. If the engagement is expected to be short or only very primitive facilities are available, manual methods may have to be employed. For long-term engagements with essentially permanent camps, as were developed in Vietnam, ADP can be used very effectively. In a forward area changes in priorities, assignments and resources can be expected to occur much more frequently than during peacetime. Computers can develop new schedules and plans much more quickly and accurately than can be accomplished manually. If properly designed, computer systems can improve a battalion's flexibility and enhance its ability to react quickly and effectively.

IV. HARDWARE AND SOFTWARE

A. INTRODUCTION

This chapter will discuss methods to improve the effectiveness of the use of computers. First, use of computers within the construction industry will be discussed, followed by discussions of hardware and software and, at the end, recommendations.

Computers are generally classified as main frames, minicomputers, or microcomputers and the distinctions between the three are not well defined. The microelectronics industry is revolutionizing the computer industry. The concept of the computer center as a room with a large computer to which users bring their work for processing is rapidly becoming obsolete. The old concept of a single computer serving all of an organization's computational needs is rapidly being replaced by one in which a large number of separate but interconnected computers do the job. No longer are users bringing work to the computer, instead computers are being brought to the users. [Ref. 17: p. 2]

B. COMPUTER USE IN THE CONSTRUCTION INDUSTRY

As stated in Chapter I, the construction industry has not made considerable use of computers except for general administrative functions; however, some firms are beginning to experiment with computers with considerable success. The following paragraphs describe some examples of typical applications.

In Anoka, Minn., a contractor uses a CPM-based scheduling program to keep track of the 400 units it builds annually. Each superintendent submits a form at the end of

the day indicating which activities were completed that day. At the end of the week, this information is fed into the computer, and the superintendent's schedule is automatically adjusted. [Ref. 18] This program sounds very similar to the CM program. It is project oriented and the total project schedule is updated by updating the individual activities within the project.

A schedule program used by a Bellevue, Washington contractor can also tell just how much impact a change - revising floor plans, for example - will have on a project's completion date [Ref. 19]. This is a more sophisticated scheduling program which allows new schedules to be developed that are caused by the inevitable changes that occur with any construction project. The CM program does allow changes to be made, but it also requires that the critical path be determined in advance so that the critical activities can be so designated.

In Seattle, a leading builder of high-rise office buildings, hotels and multi-unit housing facilities, is using a computer to keep track of construction workers and equipment. When the payroll clerks want to find out what construction job one of the workers is on, they use a query to get the information from the data base. Before they had the computer, they had to go through stacks and stacks of reports. The company's first on-line project was an equipment-management system, which instantly pinpoints the location of every piece of large equipment, no matter what project it's being used on. [Ref. 20] This seems to be a mixture of the PEOPLE and EQUIPMENT programs. The PEOPLE program will accept a company assignment, but not a project assignment. The EQUIPMENT program allows the location of the equipment to be either by organizational unit or by project.

Engineering News Record [Ref. 21] reported on a company in Belgium. Using an on-site interactive computer terminal, the head project supervisor feeds a progress report on construction activities into the machine daily. The computer identifies critical tasks (those in which a time slippage will slow the entire project) plus those which are in advance of and those running behind the schedule. The computer prints out personalized work tickets covering a two-day period for foremen and key members of the 120-man work force. In cases of unexpected problems, such as a machine out of service, the computer quickly scans alternatives and proposes a substitute schedule for men, machines and the flow of materials. This program seems to be an expansion of the CM program where many more resources per activity can be listed and alternative schedules can be determined in advance based upon resource availability and kept in the data base for future use. It might also be much more sophisticated and use file integration and resource leveling techniques.

There are also a number of other programs on the market. For example, the FRAMING CALCULATOR is a new program that computes the amount of lumber, nails, drywall and other materials, plus the number of man-hours needed to complete walls, floors, roofs, partitions and exteriors of any house. Its use requires little computer expertise and it can be run on micro or minicomputers. The information can be combined with a builder's own cost data to get quicker and more accurate estimates than are normally possible without the aid of a computer. The user can change built-in formulas to accommodate his particular circumstances.

An estimating program makes it possible for custom homebuilders and remodelers to use their computer as a marketing tool. The program is accurate to within two percent and provides:

1. A complete estimate in three or four hours with waste and inflation percentages factored in.
2. A materials take-off list that includes everything "down to the tubes of glue". The system automatically converts materials to ordering units.
3. The ability to ask "what if" questions. Custom-home buyers can make changes in the original plans and the computer will quickly recalculate a new price.

For production builders, the MODEL HOME COST EXTENSIONS APPLICATION program lets the builder compare prices among his suppliers. It contains three separate files:

1. A model master file that identifies each model the builder wishes to price.
2. A quantity file that lists the amount of material needed to build a particular model.
3. A cost file that contains a price book for each vendor.

The programs are written in BASIC and can be used on IBM 5110 and 5120, WANG 2200 series, Radio Shack TRS 80, Hewlett-Packard and Texas Instruments systems. [Ref. 22] No comparable program exists for the NCF, but such a program could be very useful at the regimental and battalion levels.

The programs used by private contractors are similar to those already provided to the battalions with the exception of the cost estimating programs and are appropriate for single project management. With the possible exception of the program in Belgium, they are not designed for resource leveling, i.e., managing a finite amount of labor or equipment resources.

C. HARDWARE

Main frames used to offer the only real computing power but minicomputers and microcomputers are beginning to challenge. Minicomputers now come with large main memories and are beginning to be used as main computers, much as main frames used to be, and can operate very well in a normal office environment.

In general, the term <u>microcomputer</u> can be defined as a stored program computer comprising memory and input/output circuits together with a microprocessor central processing unit (CPU). Microcomputers have attracted many people because of several advantages over larger computers. First, microcomputers can be used for a wide range of specific applications. Second, microcomputers are powerful, reliable, and inexpensive. They can operate effectively in environments where older computers would fail. Most off-the-shelf microcomputers operate at room temperature and require no special air conditioning or power supplies. [Ref. 23: p. 11]

The present hardware for the NMCBs is a minicomputer system and, in CONUS, has one CPU with a console keyboard visual display terminal, two five-megabyte disk units, one double floppy disk unit, one high speed printer, and one low speed printer. The hardware at most of the deployment sites consist of one CPU with two console keyboard visual display terminals, three five-megabyte disk units, one double floppy disk unit, one high speed printer, and one low speed printer. [Ref. 27]

Radio Shack is now offering a microcomputer (the TRS-80 Model 16) with one CPU and a second microprocessor for input/output, up to 512k bytes of memory, a console keyboard visual display terminal, one double floppy disk unit (1.25-megabytes per disk), up to three 8.4-megabyte hard

disk drives, one high speed printer and one low speed printer for under $30,000 [Ref. 28]. This microcomputer has more computing capacity than the existing minicomputer.

As indicated at the beginning of this chapter, single large computer systems are being replaced by a series of smaller interconnected computers. One advantage is that a number of smaller systems performing the same functions are less expensive to purchase, operate and maintain than a single large system. Another advantage is that each of the smaller computers can access and operate on the same data base, regardless of the physical location of the computers or the data base. Since each computer accesses the same data base, redundancy is built in. If one computer goes down, another computer in a different location can be used while the first is getting repaired or replaced. Interconnected computers, known as either networks or distributed systems based upon their function, bring the computer to the user and complaints concerning terminal locations and access time should be greatly reduced if not eliminated.

The networking of computers is an important concept. By placing at least one computer in each department and company (some may require two or more), networking interconnects these computers similar to a telephone system. The computers can be connected via existing telephone lines, but this requires the use of modems (modulator-demodulator). Another method is to use high band-width coaxial cables. Cables eliminate the need for the modems, allow a significant increase in the data transfer rate and are applicable for small local networks. The telephone system limits the transfer rate to about 9600 bits per second while the use of separate cables permits a rate in excess of one million bits per second [Ref. 17: p. 286]. Cables, however, are more expensive to install and maintain and make the system relatively immobile.

With a network it is not necessary that all programs or files reside on a single computer or that they be duplicated at each of the computers. The PEOPLE program, for example, could reside in Admin, the EQUIPMENT program in Alfa Company, the CM program in Charlie Company, etc. Software would provide the ability for any of the computers to access any of the programs.

Reliability is an important factor. There are several strategies available for ensuring sufficient reliability under wartime conditions. The choice depends upon balancing the reliability requirements against the cost. The reliability requirement must be defined based upon the operational uses for the equipment. Several strategies for enhancing reliability are possible. One is to "harden" the equipment. This can be accomplished by procuring MILSPEC equipment specifically designed for military applications, or it can be partially accomplished by procuring ruggedized commercial equipment. [Ref. 6: p. 2]

To acquire MILSPEC equipment essentially triples the acquisition cost and also requires a dedicated logistics support system whereas the ruggedized commercial equipment is less expensive but also less able to cope with harsh environments. This second approach generally uses small microcomputers with improved reliability but not to MILSPEC standards. Examples of ruggedized hardware include the Marine Corps' ADPE-FMF computers or the Navy's Shipboard Non-tactical Automated Processing (SNAP). A large supply of these ruggedized microcomputers is usually stocked at central locations and failures in the field are replaced with new units from the central stock with the failed unit returned for depot maintenance and restoration to the stock pool. [Ref. 6: p. 2]

D. SOFTWARE

While there are many operational similarities between the private construction industry and the NMCBs, there are also some very distinct differences. U. S. contractors normally are not self-contained and self-sufficient organizations. General contractors, who rely on union halls for labor and on subcontractors for specialized work such as mechanical, electrical, structural, etc., view their world as having unlimited resources. They have the ability to hire and fire on a daily basis and have a relatively short supply line. NMCBs on the other hand operate with a fixed number of resources and at overseas deployment sites with an extended supply line. If a piece of equipment goes down or needed material is not available, NMCBs must have the ability to shift resources quickly and effectively. Therefore, the simple programs that are used in the construction industry do not satisfy the needs of the NMCBs. To be effective, the existing programs need to be expanded and a supervisory program, a data base management system (DBMS), needs to be implemented.

A data base management system is a set of programs that operate on the data base in accordance with the user's commands [Ref. 23: p. 23]. These programs are invisible to the user, are in between the user's program and the data base, and allow the user's program to access different files within the data base. First, the design of a data base will be discussed followed by a further discussion on DBMS.

Terminology within the computer industry has not been fully standardized. For purposes of this paper, the following definitions will apply:

1. Data Base - The aggregate of all files regardless of the physical location of each of the files.
2. File - The aggregate of all similar records.

3. Records - The aggregate of all information (fields) on a particular individual, project, piece of equipment or tool, etc.
4. Field - A single attribute of a record such as name, rate, SSN, etc.

It might be said that this is the data base era in computer technology. Data base processing has grown in significance among computer scientists and also among managers of organizations. The capacities of on-line data files have grown rapidly. As capacities go up, the cost per bit of storage comes down. This situation motivates data base designers to continue their efforts to obtain better data base systems. [Ref. 23: p. 7]

An important consideration in data base design is to store data in such a way that it can be used for a wide variety of applications. By doing so, the data can be changed quickly and easily. To achieve the flexibility of data usage that is essential in most commercial situations, two aspects of data base design are important. First, the data should be independent of the programs which use it, so that it can be modified without the programs being changed (data independence). Second, it should be possible to interrogate and search the data base without the lengthy operation of writing programs in conventional programming languages. [Ref. 23: p. 7]

In designing a data base system there are many facts that should be considered. The following are among the primary objectives of data base organizations:

1. It should make applications development easier, cheaper, faster, and more flexible.
2. The data should have multiple uses.
3. Data independence.
4. Clarity. Ease of understanding what data is available to the users.

5. Flexible usage. Data can be used in flexible ways with different access paths.
6. Spontaneous requests for data can be handled easily by means of a high level query language or report generation language.
7. Change is easy.
8. Low cost.
9. Accuracy and consistency.
10. Privacy. [Ref. 23: p. 15]

In designing a multiple file data base, duplication of information between files should be kept to an absolute minimum. For example, within both the PEOPLE and MEDICAL files, each record includes fields for name, rate, company, and projected rotation date (PRD). While it is not common that there would be a name change, it cannot be considered unlikely. It is highly likely that a change will occur in rate, company and PRD. Therefore, when such a change occurs, it is necessary to update the appropriate records in both files. If only the records in one file are updated, inaccuracies and inconsistencies occur which places the integrity of both files in doubt. A DBMS can access different files by using a common field, preferably one that is highly unlikely to change. In our example, such a field could be the SSN, which presently doesn't exist in the MEDICAL file. If a SSN field were to be substituted for the name, rate, company and PRD fields in the MEDICAL file, the medical staff could generate a list of personnel by name, rate, SSN, and company overdue for a smallpox inoculation. The MEDICAL file would be sorted on the inoculation field which would identify the individual overdue records and thereby the SSN for each record. The DBMS could then access the PEOPLE file by SSN and extract the name, rate, and company from each of the appropriate records and pass that information back to Medical. If, on the other hand, the

medical staff wanted to check the status of all inoculations for all personnel with a PRD of 30 June or earlier, the PEOPLE program could be sorted on the PRD field which would identify the name, rate, SSN, and company of the appropriate individuals. The MEDICAL file could then be sorted on SSN to obtain the desired listing. With a computer network this can be accomplished even though the DBMS may reside in Operations, the MEDICAL program in Medical, and the PEOPLE program in Admin and it is not necessary that the medical staff physically run one program and then the other. They can, from a menu, request the inoculation status and the DBMS will actually invoke the two programs. Because of the Privacy Act, certain personal information is considered sensitive, but these sensitive fields can be protected allowing access only by authorized personnel.

In a similar fashion, all of the programs can be linked together, as appropriate, by establishing access (key) fields. In addition to modifying the existing programs, new programs should be designed. Two new programs that were alluded to in Chapter II were (1) a program that links safety considerations to CM activities and (2) a program that will generate an equipment operating schedule.

In the past, limited and expensive memory required that designers and programmers optimize machine efficiency. Today, as hardware and memory costs decline and software costs go up, computer scientists are placing more emphasis on software understandability and maintainability. Programming in assembly or machine language (the most primitive languages) is losing favor. The use of higher level languages, that are more English-like, and structured programming techniques will provide programs that are more understandable and maintainable. Modularizing programs, which is analogous to separating construction drawings into civil, structural, mechanical, and electrical sections, also improves maintainability: the ability to debug and modify.

The major advancement in the area of modular programming has been the development of coding techniques and assemblers which (1) allow one module to be written with little knowledge of the code in another module, and (2) allow modules to be reassembled and replaced without reassembly of the whole system. [Ref. 24: p. 220]

The benefits expected of modular programming are: (1) managerial - development time should be shortened because separate groups would work on each module with little need for communication, (2) product flexibility - it should be possible to make drastic changes to one module without a need to change others, (3) comprehensibility - it should be possible to study the system one module at a time. The whole system can therefore be better designed because it is better understood. [Ref. 24: p. 221]

The module concept allows programs to be machine independent. An interface module is used to bridge between applications programs and the machine operating system. If a machine needs to be replaced due to normal wear and tear, obsolescence, etc., only the interface module may need to be changed.

Information must be perceived before it can have value for human decision-making. The effectiveness with which a user perceives information is largely governed by the way in which it is displayed. The interface between the system and user is one of the more critical design factors. [Ref. 25: p. 27]

Some of the general principles of good display are as follows:

1. Use standard report formats, headings, and definitions whenever possible. This permits a user to scan a display without having to interpret each item.
2. Each item displayed should be labeled or have an obvious interpretation.

3. Avoid unnecessary precision. Since an aggregation inevitably represents an approximation of reality, excess precision adds little value while it clutters up the display.
4. Use graphical display when feasible. A graphical display reduces unneeded precision while often revealing relationships among variables much more perceptibly than a tabular display.
5. Provide a basis for interpreting information. A given piece of information seldom has value by itself; it must be assessed relative to some standard or anticipated result. It is therefore important that a user be provided sufficient information to comprehend the significance or surprise content of new information. This can be done by displaying the new information (e.g., actual current results) in juxtaposition with the existing plan, standard, or past results.
6. Provide links among separate displays. Each display should contain relatively little information in order not to swamp the user. It is therefore necessary to use multiple displays if much information is to be conveyed. [Ref. 25: p. 27]

In designing any hardware/software system, there are a number of crucial questions to which the system designer must find answers. One is the role of the human operator in the operation of the system. Simplicity of use will encourage users. Design considerations that involve trade-offs between simplicity and efficiency should be weighted to favor simplicity [Ref. 26: p. 46]. The man-machine interface must account for the limited computer exposure of most NMCB personnel.

E. RECOMMENDATIONS

The major expenses in computer systems at present and in the future are in software. Users in the United States spend over $10 billion for software every year. By 1985, it is estimated that computer software expenses will constitute about 90 percent of the total system cost. Therefore, the effort to expand and enhance the present systems should be directed towards the software development. Even though it is contrary to the way computer systems have been obtained in the past, the software requirements should drive the hardware requirements: make the hardware fit the software rather than vice versa. As an article in Housing recommends, decide what you need and then find the program - the software - that meets those needs. To many this sounds like buying the system backwards, since most people tend to purchase the hardware first and then the application software. But all programs do not run on all computers. It is possible, and in fact common, for a company that buys hardware to discover that the program it needs cannot run on that equipment. The hardware does the actual work, but the software controls the system and should dictate the type of equipment the company needs. [Ref. 3: p. 79]

Studies have shown that software costs rise dramatically at about the 85% saturation point of CPU and memory capacity and suggest that the following points be considered for hardware procurement:

1. Overall system cost is generally minimized by procuring computer hardware with at least 50% to 100% more capacity than is absolutely necessary.
2. The more the ratio of software-to-hardware costs increases, the more excess computing capacity one should procure to minimize the total cost.

3. It is far more risky to err by procuring a computer that is too small than one that is too large. [Ref. 29: p. 13]

Establishing computer networks, using microcomputers and/or minicomputers, at each of the deployment sites and at the battalion facilities in home port is strongly recommended. The equipment should be permanently installed at each of these locations. Some number of microcomputers could also be included as part of the battalion TOA for use by detachments or at construction sites that are remote from the main camp. Unless the computer systems are as available during home port as on deployment, continued sporadic use of the systems can be expected. The more the battalion personnel use the systems, the more familiar and the more comfortable they will become with them.

V. IMPLEMENTATION

In 1513 Machiavelli observed: "There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old system and merely lukewarm defenders in those who would gain by the new one." [Ref. 1: p. 1]

It is important for the manager not to lose sight of the many aspects which must be considered when developing a new system. It is not just a technical computer process; to the contrary, it often drastically affects and changes the basic fabric and operation of the organization. [Ref. 1: p. 1]

Many managers assume that simply installing a new machine or a new system will guarantee immediate improvement in productivity. They concentrate on the technical and supposedly "rational" aspects to the detriment of social and emotional factors. [Ref. 30: p. 480] The introduction of a system, idea, or practice may be perceived as new, an innovation, by an individual. It matters little, so far as human behavior is concerned, whether or not an idea is "objectively" new as measured by the lapse of time since its first use or discovery. It is the perceived or subjective newness of the idea for the individual that determines his reaction to it. [Ref. 31: p. 19] This reaction is a combination of the analysis of the innovation and the mental processes that individuals normally go through in making a decision whether to accept or reject.

In analyzing an innovation, the individual evaluates the following characteristics:

1. Relative advantage. This is the degree to which an innovation is perceived as better than the idea it supersedes.

2. Compatibility. This is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the receivers.
3. Complexity. This is the degree to which an innovation is perceived as difficult to understand and use.
4. Trialability. This is the degree to which an innovation may be experimented with on a limited basis. New ideas which can be tried on the installment plan will generally be adopted more quickly than innovations which are not divisible.
5. Observability. This is the degree to which the results of an innovation are visible to others. The easier it is for an individual to see the results of an innovation, the more likely he is to adopt. [Ref. 31: p. 22]

The mental process in reaching a decision to accept or reject consists of four functions or stages:

1. Knowledge. The individual is exposed to the innovation's existence and gains some understanding of how it functions.
2. Persuasion. The individual forms a favorable or unfavorable attitude toward the innovation.
3. Decision. The individual engages in activities which lead to a choice to adopt or reject the innovation.
4. Confirmation. The individual seeks reinforcement for the innovation-decision he has made, but he may reverse his previous decision if exposed to conflicting messages about the innovation. [Ref. 31: p. 101]

Knowing about an innovation is often quite different matter from using the idea. An innovation will be rejected if the individual does not regard the system as relevant to his situation, as potentially useful. Consideration of a

new idea does not pass beyond the knowldege function if the individual does not define the information as relevant to him or if he does not seek sufficient knowledge to become adequately informed so that persuasion can take place. [Ref. 31: p. 108]

An individual's attitude towards an innovation is a primary factor during the persuasion stage. A previous positive experience with the adoption of innovations creates a bank of generally favorable attitudes to change that facilitates the development of a favorable evaluation of the next innovation considered by an individual. On the contrary, a negative experience from an innovtion that is perceived as a failure leads to resistance to future new ideas. [Ref. 31: p. 110]

As the individual goes through the persuasion and decision phases, the system must retain its relative advantage and capability [Ref. 31: pp. 109 & 112]. At the confirmation stage, the individual seeks reinforcement for his decision. [Ref. 31: p. 113]. It is important to remember that the innovation-decision process can just as logically lead to a rejection decision as to adoption. In fact, each function in the process is a potential rejection point (see Figure 3.1). For instance, it is possible to reject an innovation at the knowledge function by simply forgetting about it after initial awareness. And of course rejection can occur even after a prior decision to adopt. This is discontinuance, which can occur in the confirmation function. [Ref. 31: p. 113]

If the introduction of a redesigned system is to have any success, it must be perceived as new. This will require separating the existing system from the redesigned system. The existing system, from which there have been both favorable and unfavorable experiences, should be discussed in terms of an experiment or trial to gain the knowledge and

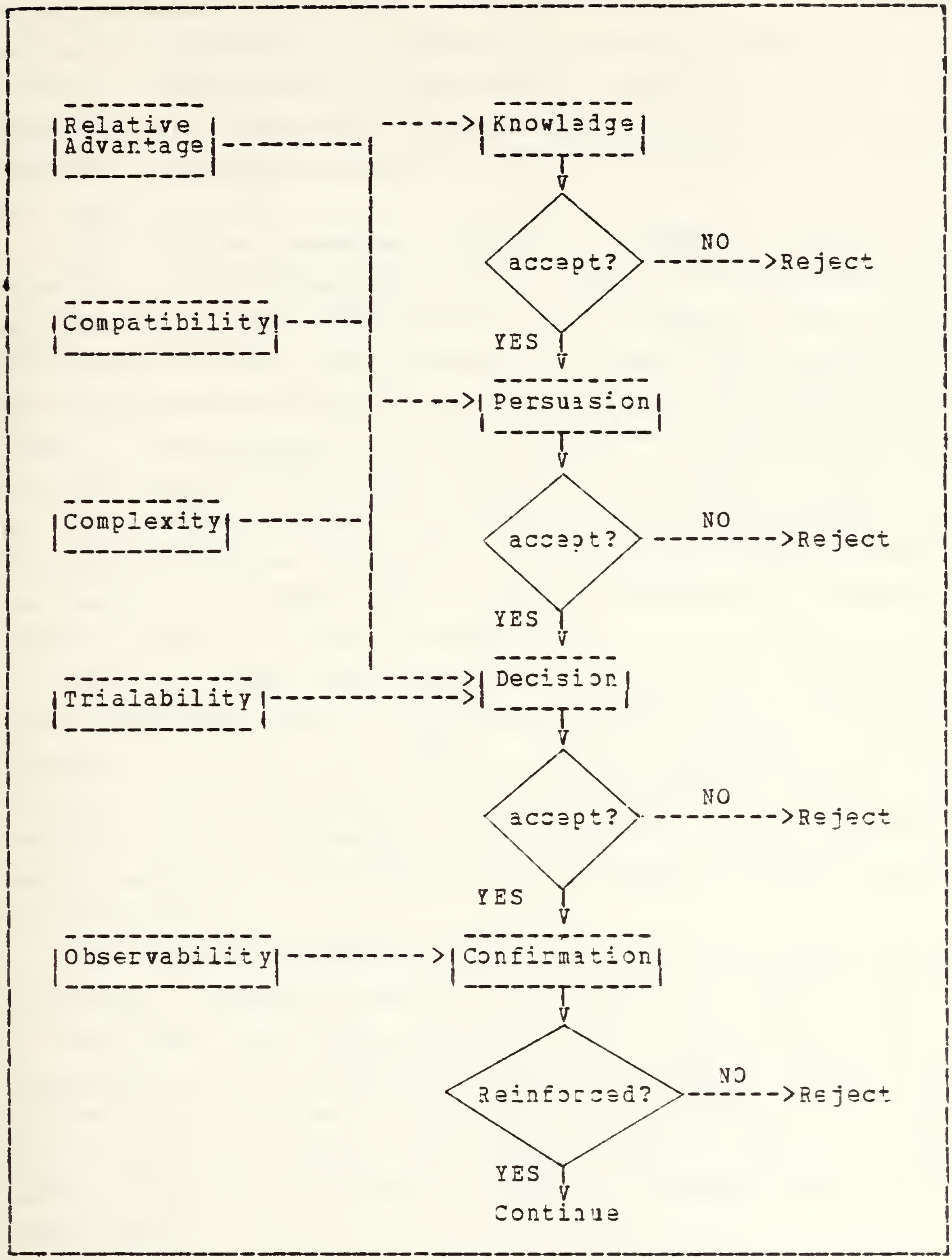

Figure 5.1 INNOVATION-DECISION PROCESS.

understanding of the needs of the battalions. If the new system is perceived as merely a rehash of the existing system, chances for a successful implementation may be significantly diminished. Each member of the battalion must perceive the redesigned system as new, relevant and useful for him.

Even if the computer system is viewed as useful in general, an individual may still resist its use because of uncertainty. The traditional ways of doing things offer precedents that can guide members' actions; the consequences of the traditional ways are at least well known and predictable. Unwillingness to give up tasks and relationships that are familiar may cause resistance to change. [Ref. 32: p. 377] Special effort should be made to demonstrate that the system provides the same information that an individual has used in the past and that this information is provided faster, easier, and more accurately.

Resistance may also occur due to perceived changes in social relationships - the patterns of authority, status and sentiment [Ref. 30: p. 480]. If the individual views the system as substituting for him as an information source, the computer may be perceived as denigrating to his position and, therefore, as a threat to his social standing within the battalion.

One method to overcome resistance is to collaborate with the users: involve them in the design and implementation. An individual who feels threatened by the computer due to uncertainty or a perceived change in social status may become more receptive to the system if he is able to participate in its creation and influence its design. This participation may also help overcome a previous unfavorable experience.

With eight battalions, this will be difficult. One approach would be to work with only one battalion during the design and initial implementation phases. Once the system has been installed and appropriate instruction has been given to all personnel, the system can be distributed to the other seven battalions, one at a time.

The contact between members of different battalions forms an informal communications network. This informal network can be used to promote or destroy the new system. If short-cuts are taken during the design or the design time is shortened with the idea of working out all the bugs during implementation, the credibility of the system could be irrepairably damaged.

The design and implementation process for a computer system is markedly different from a construction project. An inadequate design of a construction project can be compensated for during the construction phase, but not so with a computer system. If the output is incomplete or nonuseful, the system may be rejected out-of-hand and may never be accepted no matter what changes are made. It is extremely important that the preponderance of time and effort be devoted to the design so that only positive comments are communicated over the informal network during the initial implementation. If the initial battalion views the system as useful and important, acceptance by the other battalions will be enhanced.

One final matter needs to be taken into consideration. The computer systems are tools which, if properly designed and used, can be very effective in accomplishing a battalion's mission. To be accepted, their use cannot be "directed from above". Change imposed from the outside or on personal grounds ("This is the way I want things done") will be interpreted by subordinates as a sign that they have not done their jobs properly. They will feel pressured and

uncertain about why the changes are being made. Thus, instead of seeing the changes as a more effective way of reaching common objectives, organization members may resent change. [Ref. 32: p. 377]

The battalion's superiors have a legitimate need for information and the right to direct the battalions to provide that information, but they should not direct "how" that information is gathered or compiled. The battalions, as well as entities within a battalion, should have the option of using either manual or automated methods to manage their operations, including meeting their reporting requirements. If the systems are designed and implemented as tools to meet the needs of the users, it is felt that the users, on their own, will opt for automation.

APPENDIX A
SURVEY RESULTS

How would you characterize the CM4 program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	-	2	-	-	1
O4	1	1	-	1	5
O3	2	4	1	1	7
O2	-	4	-	-	1
O1	1	2	-	-	2
E9	-	1	1	-	3
E8	1	1	-	-	1
E7	5	9	1	1	4
E6	10	4	2	-	6
E5	-	2	1	1	5
E4	1	2	-	-	3
E3	-	2	-	-	3
TOTAL	21	34	6	4	41

N = 106 respondents

How would you characterize the WORD PROCESSING program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	-	1	2	-	-
O4	-	-	1	2	5
O3	-	1	1	2	11
O2	-	-	-	-	5
O1	-	-	2	-	3
E9	-	-	-	-	5
E8	-	-	-	-	3
E7	1	-	-	1	18
E6	2	1	-	1	18
E5	1	1	-	-	7
E4	3	-	-	-	3
E3	-	1	-	-	4
TOTAL	7	5	6	6	82

How would characterize the PEOPLE program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	2	1	-	-	-
O4	2	3	1	1	1
O3	3	3	1	1	7
O2	1	-	-	-	4
O1	2	-	-	-	3
E9	1	1	2	1	-
E8	-	3	-	-	-
E7	3	7	-	2	8
E6	6	7	1	1	7
E5	2	2	-	-	5
E4	3	-	1	-	2
E3	-	3	1	-	1
TOTAL	25	30	7	6	38

How would you characterize the SAFETY program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	-	-	-	-	3
O4	-	-	-	1	7
O3	-	-	-	1	14
O2	-	-	-	-	5
O1	-	-	-	-	5
E9	-	1	-	-	4
E8	-	2	-	-	1
E7	-	1	-	-	19
E6	2	2	-	-	18
E5	-	1	1	-	7
E4	-	1	-	-	5
E3	-	-	-	-	5
TOTAL	2	8	1	2	93

How would you characterize the MEDICAL program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	1	-	-	-	2
O4	-	-	-	2	6
O3	-	1	1	-	13
O2	-	-	-	-	5
O1	-	-	-	-	5
E9	-	-	-	-	5
E8	-	-	-	-	3
E7	-	-	-	1	19
E6	1	-	-	-	21
E5	1	1	1	-	6
E4	1	2	-	-	3
E3	-	-	-	-	5
TOTAL	4	4	2	3	93

How would you characterize the EQUIPMENT program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	1	-	-	-	2
O4	1	-	-	1	6
O3	-	2	-	-	13
O2	-	-	-	-	5
O1	1	-	-	-	5
E9	-	1	1	-	3
E8	-	1	-	-	2
E7	1	4	-	-	15
E6	6	1	2	-	13
E5	2	3	-	-	4
E4	3	2	-	-	1
E3	-	-	-	-	5
TOTAL	15	14	3	1	73

How would you characterize the TOOL program output?

GRADE	VERY GOOD	GOOD	AVERAGE	POOR	NO OPINION
O5	-	1	-	-	2
O4	-	-	-	1	7
O3	-	1	-	1	13
O2	-	-	-	-	5
O1	1	-	-	-	4
E9	-	1	-	1	3
E8	-	1	-	-	2
E7	-	3	-	-	17
E6	4	1	3	-	14
E5	-	1	-	-	8
E4	1	1	-	-	4
E3	-	-	-	-	5
TOTAL	6	10	3	3	84

If marked POOR, reason is?

GRADE	INACCURATE INFO	NON-TIMELY INFO	NON-USEFUL FORMAT	BROADEN SCOPE	OTHER	N/A
O5	-	-	-	-	1	2
O4	1	-	-	1	-	6
O3	-	-	3	1	-	11
O2	-	-	-	-	1	4
O1	-	-	-	-	-	5
E9	2	-	-	-	-	3
E8	-	-	-	-	-	3
E7	2	-	-	-	1	17
E6	-	-	-	1	2	19
E5	-	-	-	1	-	8
E4	-	-	-	-	1	5
E3	-	-	-	1	-	4
TOTAL	5	-	3	5	6	87

How often did you use CM4?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	2	-	1
O4	-	-	1	6
O3	-	2	5	8
O2	-	2	2	1
O1	-	1	2	2
E9	-	-	2	3
E8	-	1	1	1
E7	-	9	6	5
E6	1	2	13	6
E5	1	-	1	7
E4	2	1	-	3
E3	-	-	2	3
TOTAL	4	20	35	47

How often did you use WORD PROCESSING?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	1	2	-
O4	-	-	2	6
O3	-	2	1	12
O2	-	-	-	5
O1	-	1	1	3
E9	-	-	-	5
E8	-	-	-	3
E7	-	1	1	18
E6	-	1	2	19
E5	1	-	1	7
E4	3	-	-	3
E3	-	-	2	3
TOTAL	4	6	12	84

How often did you use PEOPLE?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	1	2	-	-
O4	2	-	4	2
O3	1	3	4	7
O2	-	2	-	3
O1	-	1	-	4
E9	2	2	1	-
E8	-	-	1	2
E7	2	5	4	9
E6	4	4	5	9
E5	3	1	-	5
E4	3	-	1	2
E3	1	1	2	1
TOTAL	19	21	22	44

How often did you use SAFETY?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	1	-	2
O4	-	-	-	8
O3	-	-	-	15
O2	-	-	-	5
O1	-	-	-	5
E9	-	1	1	3
E8	-	-	1	2
E7	-	1	-	19
E6	2	-	2	18
E5	-	-	1	8
E4	1	-	-	5
E3	-	-	-	5
TOTAL	3	3	5	95

How often did you use MEDICAL?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	1	-	2
O4	-	-	1	7
O3	-	1	-	14
O2	-	-	-	5
O1	-	-	-	5
E9	-	-	-	5
E8	-	-	-	3
E7	-	-	1	19
E6	-	-	1	21
E5	-	3	-	6
E4	-	3	-	3
E3	-	-	-	5
TOTAL	-	8	3	95

How often did you use EQUIPMENT?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	1	-	2
O4	1	-	-	7
O3	-	-	1	14
O2	-	-	-	5
O1	-	-	-	5
E9	1	-	1	3
E8	-	1	-	2
E7	-	2	3	15
E6	2	3	4	13
E5	3	-	2	4
E4	3	1	1	1
E3	-	-	-	5
TOTAL	10	8	12	76

How often did you use TOOL?

GRADE	DAILY	FREQUENTLY	OCCASIONALLY	NEVER
O5	-	1	-	2
O4	-	-	1	7
O3	-	-	1	14
O2	-	-	-	5
O1	-	-	-	5
E9	1	-	2	2
E8	-	-	1	2
E7	-	1	2	17
E6	2	2	4	14
E5	-	-	2	7
E4	1	1	-	4
E3	-	-	-	5
TOTAL	4	5	13	84

Were you given a specific time to use the computer?

GRADE	YES	NO	N/A
05	1	-	2
04	3	3	2
03	4	8	3
02	-	-	5
01	3	1	1
E9	2	1	2
E8	2	1	-
E7	10	4	6
E6	6	9	7
E5	6	1	2
E4	2	3	1
E3	1	2	2
TOTAL	40	33	33

If YES, was the time convenient?

GRADE	YES	NO	N/A
05	-	-	3
04	2	1	5
03	4	-	11
02	1	-	4
01	3	-	2
E9	2	1	2
E8	1	-	2
E7	7	3	10
E6	3	4	15
E5	6	-	3
E4	3	-	3
E3	1	-	4
TOTAL	33	9	64

If YES, was time during normal working hours?

GRADE	YES	NO	N/A
O5	-	-	3
O4	3	-	5
O3	4	-	11
O2	1	-	4
O1	3	-	2
E9	2	1	2
E8	-	1	2
E7	5	4	11
E6	6	1	15
E5	6	-	3
E4	2	-	4
E3	1	-	4
TOTAL	33	7	66

If YES, did you have to wait beyond appointed time?

GRADE	USUALLY	SOMETIMES	SELDOM	NEVER	N/A
O5	-	-	-	-	3
O4	1	-	1	2	4
O3	-	1	1	3	10
O2	-	-	-	1	4
O1	-	1	1	2	1
E9	-	3	-	-	2
E8	-	2	-	-	1
E7	2	3	6	-	9
E6	-	2	5	1	14
E5	-	1	2	4	2
E4	-	-	-	4	2
E3	-	1	1	-	3
TOTAL	3	14	17	17	55

If NO, could you get access during normal working hours?

GRADE	USUALLY	SOMETIMES	SELDOM	NEVER	N/A
05	-	-	-	-	3
04	2	1	-	-	5
03	4	1	1	-	9
02	-	1	-	-	4
01	3	-	-	-	2
E9	2	-	-	-	3
E8	-	1	1	-	1
E7	3	-	1	-	16
E6	3	3	2	1	13
E5	3	-	-	-	6
E4	6	-	-	-	-
E3	1	-	1	-	3
TOTAL	27	7	6	1	65

Did you have to go on a waiting list?

GRADE	YES	NO	N/A
05	-	-	3
04	-	3	5
03	-	6	9
02	1	1	3
01	-	2	3
E9	-	2	3
E8	2	-	1
E7	3	5	12
E6	4	6	12
E5	-	4	5
E4	-	6	-
E3	1	3	1
TOTAL	11	38	57

Did you have to wait in line?

GRADE	YES	NO	N/A
O5	-	-	3
O4	-	3	5
O3	-	6	9
O2	1	1	3
O1	-	2	3
E9	-	2	3
E8	-	2	1
E7	2	6	12
E6	2	8	12
E5	-	4	5
E4	-	6	-
E3	2	2	1
TOTAL	7	42	57

Were the terminal locations convenient?

GRADE	CONVENIENT	INCONVENIENT	NO OPINION
O5	1	1	1
O4	4	4	-
O3	10	3	2
O2	5	-	-
O1	1	3	1
E9	2	3	-
E8	1	1	1
E7	13	5	2
E6	11	8	3
E5	6	2	1
E4	5	1	-
E3	5	-	-
TOTAL	64	31	11

Is the input data format understandable?

GRADE	YES	NO	N/A
O5	-	-	3
O4	6	-	2
O3	10	1	4
O2	3	-	2
O1	4	-	1
E9	2	-	3
E8	1	-	2
E7	15	-	5
E6	22	-	-
E5	8	-	2
E4	5	-	1
E3	5	-	-
TOTAL	81	1	24

Is the input data format convenient to use?

GRADE	YES	NO	N/A
O5	-	-	3
O4	4	2	2
O3	10	1	4
O2	3	-	2
O1	3	1	1
E9	1	1	3
E8	1	-	2
E7	12	1	7
E6	20	1	1
E5	7	-	2
E4	5	-	1
E3	3	1	1
TOTAL	69	8	29

How long have you been exposed to the system?

GRADE	1 YR OR LESS	2 YRS	3 YRS
O5	2	1	-
O4	6	2	-
O3	13	2	-
O2	5	-	-
O1	4	1	-
E9	3	2	-
E8	3	-	-
E7	13	2	5
E6	18	2	2
E5	7	2	-
E4	5	1	-
E3	5	-	-
TOTAL	84	15	7

Do you find the computer to be a useful tool?

GRADE	YES	NO	NO OPINION
O5	3	-	-
O4	5	2	1
O3	10	-	5
O2	5	-	-
O1	3	1	1
E9	4	1	-
E8	3	-	-
E7	17	2	1
E6	22	-	-
E5	9	-	-
E4	6	-	-
E3	5	-	-
TOTAL	92	6	8

What is the CM4 potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	-	1	-
O4	2	2	1	3
O3	4	2	2	7
O2	2	-	1	2
O1	2	1	1	1
E9	1	-	-	4
E8	1	1	1	-
E7	11	1	-	8
E6	11	2	-	9
E5	3	-	-	6
E4	3	-	1	2
E3	2	2	-	1
TOTAL	44	11	8	43

What is the WORD PROCESSING contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	1	-	-
O4	3	1	1	3
O3	4	3	1	7
O2	-	1	-	4
O1	2	-	1	2
E9	1	-	-	4
E8	-	-	2	1
E7	4	1	1	14
E6	5	3	-	14
E5	1	1	1	6
E4	3	-	1	2
E3	2	-	-	3
TOTAL	27	11	8	60

What is the PEOPLE potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	3	-	-	-
O4	5	2	-	1
O3	5	3	-	7
O2	1	-	-	4
O1	3	-	1	1
E9	3	-	-	2
E8	1	2	-	-
E7	10	-	-	10
E6	9	3	-	10
E5	3	-	1	5
E4	3	1	-	2
E3	3	2	-	-
TOTAL	49	13	2	42

What is the SAFETY potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	1	1	1	-
O4	-	1	3	4
O3	-	2	4	9
O2	-	1	-	4
O1	-	1	2	2
E9	1	-	-	4
E8	-	3	-	-
E7	3	1	-	16
E6	2	4	1	15
E5	-	1	2	6
E4	1	-	1	4
E3	-	3	-	2
TOTAL	8	18	14	56

What is the MEDICAL potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	-	1	-
O4	3	2	-	3
O3	3	3	1	8
O2	1	-	-	4
O1	-	2	1	2
E9	1	-	-	4
E8	-	-	2	1
E7	3	-	1	16
E6	4	-	1	17
E5	3	1	1	4
E4	3	-	1	2
E3	1	1	-	3
TOTAL	24	9	9	64

What is the EQUIPMENT potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	1	-	-
O4	3	1	-	4
O3	4	1	2	8
O2	-	1	-	4
O1	3	-	1	1
E9	2	-	-	3
E8	1	-	1	1
E7	8	1	-	11
E6	5	4	-	13
E5	4	-	-	5
E4	5	-	-	1
E3	1	3	-	1
TOTAL	38	12	4	52

What is the TOOL potential contingency contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	1	-	-
O4	2	3	1	2
O3	4	3	-	8
O2	-	1	-	4
O1	1	-	2	2
E9	2	-	-	3
E8	-	2	1	-
E7	7	2	-	11
E6	5	2	1	14
E5	-	2	1	6
E4	2	-	1	3
E3	-	4	-	1
TOTAL	25	20	7	54

What is the CM4 peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	-	2	1	-
O4	-	2	3	3
O3	1	3	4	7
O2	3	-	-	2
O1	1	2	1	1
E9	-	1	-	4
E8	-	1	1	1
E7	6	4	-	10
E6	7	4	1	10
E5	3	-	-	6
E4	2	1	1	2
E3	2	2	-	1
TOTAL	25	22	12	47

What is the WORD PROCESSING peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	-	2	1	-
O4	1	2	2	3
O3	1	2	4	8
O2	-	1	-	4
O1	2	1	-	2
E9	-	-	1	4
E8	-	-	2	1
E7	3	1	2	14
E6	3	3	-	16
E5	1	1	1	6
E4	3	-	1	2
E3	1	-	1	3
TOTAL	15	13	15	63

What is the PEOPLE peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
O5	2	-	1	-
O4	3	3	1	1
O3	2	5	1	7
O2	1	-	-	4
O1	3	-	1	1
E9	1	1	-	3
E8	1	1	-	1
E7	9	1	1	9
E6	6	4	1	11
E5	3	-	1	5
E4	3	1	-	2
E3	3	2	-	-
TOTAL	37	18	7	44

What is the SAFETY peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
05	-	2	1	-
04	-	1	3	4
03	-	2	3	10
02	-	1	-	4
01	-	-	3	2
E9	-	1	-	4
E8	-	2	-	1
E7	3	1	1	15
E6	1	5	-	16
E5	-	1	2	6
E4	1	-	1	4
E3	-	1	1	3
TOTAL	5	17	15	69

What is the MEDICAL peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
05	-	2	1	-
04	1	2	-	5
03	2	2	2	9
02	1	-	-	4
01	-	1	2	2
E9	-	-	1	4
E8	-	-	2	1
E7	2	1	2	15
E6	1	3	-	18
E5	3	1	1	4
E4	2	1	1	2
E3	1	-	1	3
TOTAL	13	13	13	67

What is the EQUIPMENT peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
05	-	2	1	-
04	2	1	-	5
03	1	5	1	8
02	-	1	-	4
01	3	-	1	1
E9	-	2	-	3
E8	1	-	1	1
E7	5	1	-	14
E6	4	4	-	14
E5	3	1	-	5
E4	4	1	-	1
E3	-	2	1	2
TOTAL	23	20	5	58

What is the TOOL peacetime contribution?

GRADE	MAJOR	MODERATE	LITTLE/NO	NO OPINION
05	-	2	1	-
04	2	2	-	4
03	1	1	4	9
02	-	1	-	4
01	1	-	2	2
E9	1	-	1	3
E8	-	1	1	1
E7	4	1	-	15
E6	3	3	1	15
E5	-	2	1	6
E4	2	-	1	3
E3	-	2	1	2
TOTAL	14	15	13	64

Has CM4 helped improve the execution plan?

GRADE	YES	NO	NO OPINION
O5	1	1	1
O4	1	2	5
O3	2	9	4
O2	2	-	3
O1	3	-	2
E9	-	1	4
E8	1	-	2
E7	11	1	8
E6	13	1	8
E5	4	1	4
E4	3	1	2
E3	3	-	2
TOTAL	44	17	45

Has CM4 helped improve project planning?

GRADE	YES	NO	NO OPINION
O5	1	1	1
O4	2	2	4
O3	5	6	4
O2	3	-	2
O1	3	-	2
E9	1	1	3
E8	2	-	1
E7	14	-	6
E6	17	1	4
E5	6	-	3
E4	5	-	1
E3	4	-	1
TOTAL	63	11	32

Has CM4 helped improve productivity?

GRADE	YES	NO	NO OPINION
05	1	1	1
04	1	2	5
03	3	8	4
02	3	-	2
01	2	-	3
E9	-	1	4
E8	2	-	1
E7	9	3	8
E6	14	1	7
E5	6	-	3
E4	4	-	2
E3	3	-	2
TOTAL	48	16	42

Has CM4 helped improve readiness?

GRADE	YES	NO	NO OPINION
05	1	1	1
04	-	3	5
03	3	8	4
02	1	1	3
01	2	-	3
E9	-	1	4
E8	2	-	1
E7	6	5	9
E6	14	1	7
E5	5	1	3
E4	3	1	2
E3	3	-	2
TOTAL	40	22	44

Do you maintain duplicate records manally?

GRADE	YES	NO	NO OPINION
O5	1	1	1
O4	4	4	-
O3	9	5	1
O2	2	3	-
O1	3	1	1
E9	2	1	2
E8	2	1	-
E7	15	4	1
E6	14	4	4
E5	4	4	1
E4	4	2	-
E3	1	4	-
TOTAL	61	34	11

Have you been able to substitute a report?

GRADE	YES	NO	NO OPINION
O5	1	-	2
O4	5	2	1
O3	6	8	1
O2	4	1	-
O1	3	2	-
E9	-	3	2
E8	2	1	-
E7	13	7	-
E6	16	5	1
E5	7	1	1
E4	6	-	-
E3	4	1	-
TOTAL	67	31	8

Has there been an impact due to the system being down?

GRADE	YES	NO	NO OPINION
O5	-	3	-
O4	1	6	1
O3	6	7	2
O2	2	3	-
O1	1	3	1
E9	-	2	3
E8	-	2	1
E7	11	8	1
E6	4	18	-
E5	3	6	-
E4	2	4	-
E3	2	3	-
TOTAL	32	65	9

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